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ABSTRACT

Recognizing that a crisis exists in engineering education, several state professional engineering societies have taken the lead in identifying and helping to solve problems related to engineering education on a state level. The National Society of Professional Engineers (NSPE), believing that NSPE state societies are ideally structured to assume a leadership role in this effort, has developed this guide to aid their state societies in efforts to eliminate the engineer education crisis. The nature of the engineering education problem (focusing on faculty shortage, graduate students, laboratory equipment and pre-college deficiencies) is discussed in the first chapter. Methodology, results, and conclusions of an NSPE study to determine what was being done by state societies to stimulate aid from various sources for engineering colleges is reported in the second chapter. Efforts of other groups on behalf of engineering education are discussed in the third chapter. Specific steps, methods, groups, documents, and other aspects of state society efforts to secure aid for their engineering colleges are outlined in the fourth chapter. Three case studies illustrating how the Alabama, Florida, and Texas state societies proceeded with successful projects, are discussed in the fifth chapter. The final chapter provides six major recommendations to help resolve the current crisis. (JN)

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A Guide to Action for NSPE State Societies

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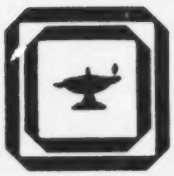
ENGINEERING EDUCATION PROBLEMS:
A GUIDE TO ACTION
FOR NSPE STATE SOCIETIES



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FOREWORD

The "Crisis in Engineering Education" is real. The potential long-term effect of this crisis can be a severe negative impact on the nation's economic well-being and on our ability to maintain a strong defense. U.S. News and World Report, March 15, 1982, succinctly describes why engineering is so important: "Because, in a high-technology society racked by fierce international competition, engineers' performances can decide the survival or withering of an industry--prosperity and paychecks or unemployment and hunger." Noting the shift in technological edge to other nations, U.S. News, in the same article, stated, "Engineering lag is related to a long-recognized fall-off in the U.S. while Japan, West Germany and France have scored gains based on increased effort in the field."

Recognizing the critical nature of the issue, a number of state professional engineering societies have taken the lead in identifying and helping to solve problems related to engineering education on a state level. NSPE believes the problem must be addressed at that level and that the state societies of the National Society of Professional Engineers are ideally structured to assume the leadership role in this effort.

There are three major components of the crisis in engineering education:

1. The present lack of faculty is serious as are the disastrous projections for the future. At the present time there is approximately a 9% faculty vacancy rate in the schools of engineering. At the assistant professor level the vacancy rate is 25%. In addition, many schools are far below the needed strength in authorized positions in order to handle the number of students. This translates into a shortfall of approximately 20 to 40% for faculty in the schools of engineering.

2. There is a deficiency in the overall number and distribution by field of specialization of engineering graduate students which are the eventual source of the needed faculty members. The number of Ph.D. candidates is inadequate, and the ratio of American-born candidates is decreasing even more rapidly. These conditions and the strong competition from industry for engineers severely restrict the number of individuals available to enter the academic field. The supply is less than one-fourth the demand.

3. Laboratory equipment is outdated. A recent study indicates that equipment in most academic engineering labs is about twice as old as that in industrial labs. Further, accreditation results show drastic declines in the effectiveness of the laboratory portions of engineering curricula as a result of equipment deficiencies. The Accreditation Board for Engineering and Technology (ABET) reports that over one half of the accreditation visits result in something less than full accreditation. Deficiencies in equipment is a significant element in the majority of these cases.

There is no doubt remaining that there is a nationwide crisis in engineering education. NSPE believes its state societies and the individual members who make up those state organizations can initiate efforts that will help to eliminate the engineering education crisis. This manual describes several success stories and a variety of suggestions for action programs in your state. The manual is a tool. It is the essence of NSPE's mission--response to the problem with solutions.

Chapter 1

THE ENGINEERING EDUCATION PROBLEM

Faculty Shortages

There is little doubt that compensation level is a major contributor to the faculty shortage. Given the alternatives of moving into the industrial employment market or remaining on campus for graduate degree study, very few undergraduate engineering students elect the latter. The reason is clear. The average starting salary for the baccalaureate engineering graduate was $25,000 as of January 1, 1982. By contrast, to remain on campus as a graduate student, there is relative assurance of nothing more than a very modest stipend of less than $10,000. Furthermore, the National Association of State Universities and Land Grant Colleges reported an academic year 1981-82 salary average of $24,997 for assistant professors. This means that experienced engineers with one to five years of experience and working as assistant professors of engineering earned less than beginning engineers.

The discrepancy in compensation continues to impact negatively upon faculty stability. In a study conducted by Frank J. Atelsek and Irene L. Gomberg for the National Science Foundation (NSF), the Department of Education and the National Endowment for the Humanities, a common conclusion was that compensation had a major negative effect on the number of engineers in faculty positions. Institutions reported that superior salary and financial benefits were cited as the reason for the move in 76 percent of the cases where engineering faculty members left for jobs in industry. The attractiveness of employment in other than educational institutions is demonstrated at each step along the career path.

TABLE 1
Salaries of Engineers by Employment Area and Experience Level

Years of Experience	Education	All Manufacturing (median numbers)	Construction	Consultant	Transportation
5 through 9	$25,000	$30,000	$30,000	$28,500	$30,912
10 through 14	$30,000	$35,000	$37,142	$35,000	$31,387
20 through 24	$34,900	$40,150	$49,550	$44,500	$40,845

Source: Professional Engineer Income and Salary Survey - 1981, NSPE

The only employment area in the NSPE survey to reflect a salary level consistently lower than that associated with education was that of engineers employed by state and local governments.

Another factor in the faculty shortage is the decrease in the attractiveness and the quality of the university environment as perceived by the faculty and prospective faculty. This makes the task of attracting even a portion of the best engineers to an academic career very difficult. This perceived degradation of the engineering academic environment comes about because of heavy teaching loads, antiquated and inadequate equipment and declining technical and staff support resources.

Graduate Students

There is a valid and constant need for more engineering graduate students if engineering schools are to maintain the desired level of faculty quality and quantity and simultaneously provide a strong R&D base for industry. However, the number of graduate students is dangerously low and is not likely to increase under the present circumstances. Increased incentives must be provided for engineering students to remain on campus to continue with graduate work.

The large proportion of engineering graduate students who are not native-born Americans aggravates the problem even more. The following statistics demonstrate the magnitude of this issue:

TABLE 2
U.S. Engineering Degrees 1950-1980

	Bachelors Degrees		Masters Degrees		Doctoral Degrees	
Year Ending	Foreign Nationals	Total	Foreign Nationals	Total	Foreign Nationals	Total
1971	1,565	43,167	2,930	16,383	741	3,640
1975	2,468	38,210	3,250	15,773	891	3,138
1980	4,895	58,742	4,512	17,243	982	2,751

Source: Data Related to the Crisis in Engineering Education, American Association of Engineering Societies, 1981

This trend has already resulted in some very serious problems and portends more in the future. First, it means the pool of potential native-born Americans to fill faculty positions is severely limited. In 1980, according to the National Research Council, 46.3 percent of all engineering doctorates went to non-citizens of the United States, two-thirds of whom leave the U.S. after receiving their doctorate. Secondly, the influx of foreign-born faculty has resulted in significant communications barriers in the classroom, causing teaching quality to suffer.

A study by the Congressional Research Service, "United States Supply and Demand of Scientists and Engineers: Effects on Defense and Research and Technology," describes another dimension of the non-citizen engineering student concern. The report states, "The Department of Defense is greatly concerned about the increase of foreign national students, the NSF notes, because the DOD must hire U.S. citizens. Due to a significant increase in the number of foreign national students in some science and engineering fields, it is believed that in the near future very few U.S. citizens in these fields will be available for hiring. In addition, foreign students pose a technology transfer problem that is particularly troublesome for the military."

Laboratory Equipment

Advanced laboratory equipment is critically important if engineering schools are to provide the type of educational opportunities that industry desires. There is a critical shortage of such equipment in many engineering schools. Although some of the more renowned engineering institutions in the nation are blessed with ample endowments and modern facilities and equipment, the facilities in the average engineering college, according to General E. T. Marsh, Commander, Air Force & Systems Command, USAF, are 30 years old. General Marsh, writing in Defense magazine, goes on to point out that the acceleration of technological progress in recent years has "exacerbated the problem of outdated laboratory equipment." He cites a recent NSF study that indicated that the median age of "university instrumentation is twice that of the instrumentation in two major companies." The estimated cost to bring engineering colleges' laboratory facilities up to today's level of technology is enormous.

Dr. Daniel C. Drucker, Dean of Engineering, University of Illinois, in a statement issued in April 1981, put the cost in these terms: "The Association of Independent Engineering Colleges estimated a few years ago that $1,500 per B.S. graduate is needed each year to maintain adequate undergraduate laboratories. That figure is quite close to the maintenance cost of $100,000,000/year for an over one-billion-dollar equipment

total with a lifetime of 10 years on the average. Unfortunately, the instructional equipment deficiencies of the past decade have made most of the present equipment obsolete. These deficiencies continue so that there is about a billion-dollar equipment catch-up problem in instructional laboratories.

There have been other estimates which, while they vary in degree, are nevertheless in the same order of magnitude. The ability of most engineering institutions to catch up is nil.

Pre-College Deficiencies

Engineering education problems have roots extending back into the elementary and secondary schools of the United States. Senator Harrison Schmitt stated before the House Committee on Science and Technology that "the manpower with which we are concerned will for the most part require deep understanding in the sciences or engineering, which in turn will rest on solid education in mathematics and science. Our problems originate in the earliest school years and are compounded throughout the educational process.

"An estimated five percent of our high school students take no math or science courses beyond the 10th grade and math SAT scores declined steadily from the early 1960s through 1980. It is estimated that there are only 10,000 physics teachers in the nation's more than 15,000 school districts. Students are not only precluding their opportunities for scientific or technical careers but are even jeopardizing their abilities to function successfully in an increasingly technologically complex society. Until families, local school boards and state governments demand new curriculum requirements and academic rigor, major improvements are unlikely."

Conclusion

Several major problems of engineering colleges have been tragically neglected to the extent that they are a national disgrace and a human disaster. The cost of rectifying these problems will be high but not exorbitant, considering the far-reaching benefits that all residents of the country derive from engineering brainpower. The current situation is intolerable and cannot be permitted to exist. To improve it, NSPE will work in the halls of Congress, with the Executive Branch of the U.S. government, and with national industries and organizations to bring resources to bear upon the problem. Furthermore, NSPE will work with its state organizations and chapters to secure aid for engineering education from state government and industry. The results of state-level efforts are described in the following section.

Chapter 2

NSPE STATE SOCIETY EFFORTS TO SECURE AID FOR ENGINEERING EDUCATION

Background and Methodology

A study was conducted to determine what was being done by NSPE's state societies to stimulate aid from various sources for engineering colleges, what methods had been utilized and what the results were. The study consisted of a written questionnaire that was mailed to all 54 NSPE societies in the United States and its territories. A structured telephone follow-up interview was conducted to secure additional information that did not lend itself to a written format. The questionnaires were sent to both the state society's office and president. Follow-up calls were made to the person listed on the completed written questionnaire, the state executive director, or both. In several instances third and fourth parties were phoned to secure relevant information.

Results and Discussion

Responses were secured from 96 percent of the state and territorial societies of NSPE.

Ten societies reported having completed a project through the first funding phase and played major roles in securing aid of various types for engineering colleges, as summarized in Table 3.

TABLE 3
Aid for Engineering
Education in Ten States

Actually Secured

1. State Aid Actually Secured - $34,500,000
2. Industry Aid Actually Secured - $ 6,500,000
3. Engineering Faculty Salary Increase (Not for Faculty in All Fields) - 4 states (Florida, Kansas, Texas, Calif)
4. Faculty Salary Increases for all Fields - 3 states (California, Nebraska, Texas)

Pending In Current Legislation

1. $82,000,000 in Aid to Engineering Colleges
2. Pay Increases for Engineering Faculties Only Pending in One State (Nebraska)

Results in the ten states are significant and adequate to dispel several commonly proclaimed misconceptions: (1) that it is virtually impossible to secure differential pay scales for engineering faculties; (2) that industry and engineering cannot work together to achieve desirable ends; and (3) that problems of the magnitude of the crisis in engineering education are beyond the capabilities of the state societies to effect a significant impact. While the $82,000,000 currently included in pending legislation has not been enacted, and only a portion most probably will ever materialize, it attests to the effectiveness of the state societies in the legislative arena.

The following states have completed a program to secure aid for engineering colleges through the first funding phase:

Alabama	Kentucky
California	Nebraska
Florida	New Mexico
Iowa	Texas
Kansas	Virginia

The following state societies had programs under way as of April 1, 1982, but had not yet reached the funding phase:

Arkansas	Louisiana	North Dakota
Georgia	Michigan	Oklahoma
Hawaii	Mississippi	Washington
Illinois	North Carolina	West Virginia

There does not appear to be any particular characteristic that distinguishes the states that have decided to actively try to stimulate aid for engineering education. Some are large, others small; some rural, others highly urbanized; some very industrialized, others heavily agrarian; and they are distributed geographically.

Aid sought by both those state societies that have secured funds and those that are in the process of doing so falls into the categories of faculty salaries, facilities, laboratory equipment and miscellaneous. Table 4 summarizes the state society activities in terms of types of aid sought and obtained.

TABLE 4
Engineering College Aid Targets
By Type in State Society Efforts

Purposes	Targets (No. of State Societies Attempting)		
	State Leg. & Governor	Admin. & Regents	Industry
Eng. Fac. Shortages	5/11/16	3/8/11	3/7/10
Eng. Fac. Salaries	5/8/13	3/7/10	2/5/7
Ind. Sponsored Research	1/2/3	0/2/2	0/1/1
Faculty Exchanges	4/3/7	2/2/4	2/2/4
Eng. Lab. Equipment	4/10/14	1/7/8	1/7/8
Incr. No. of Grad Students	2/3/5	1/3/4	1/2/3
Eng. School Facilities	6/7/13	2/5/7	2/4/6
Curric. Improv.	1/2/3	1/3/4	0/1/1
Incent. for Bus. Aid to Eng. Colleges			

Note: 5/11/16 indicates that 5 states completed program through first funding phase,/11 states with programs under way but not completed through first funding phase,/16 is total of both. This coding of the data applies to Tables 4 and 5.

Emphasis of most state society efforts is being directed toward the faculty shortage in engineering colleges, with salary increases as a primary goal, and toward engineering laboratory instructional equipment and facilities. State legislatures and governors are receiving most attention, with the university administration, state boards of regents, and industry being appropriately included. In all, the data indicate that the NSPE state societies that have programs under way have identified specific priorities for improvement of their particular engineering college(s) and have communicated the problems to all major parties who can be of assistance. Table 5 shows that the state society programs have been mostly directed toward securing more financial aid for engineering education from state government, but with a noteworthy effort to stimulate industry to provide resources. In several states, economic and political conditions necessitated that the state society attempt to secure a greater share of existing state funds for engineering education by a reallocation process.

TABLE 5
Objectives of State Society Efforts to
Secure Aid for Engineering Colleges

No. of States	Objectives
10/10/20	More national financial aid More state financial aid
2/6/8	Greater share of existing state funds for engineering education via reallocation
5/7/12	More outside financial aid from private sector (industry, business, alumni, etc.)
0/1/1	Direct state society aid

Conclusion

NSPE's State Societies can significantly increase the amount of financial resources available to engineering colleges to overcome deficiencies and improve the quality of engineering education by utilizing a carefully planned strategy, valid relevant data, and close cooperation with industry and engineering society chapters.

Chapter 3

EFFORTS OF OTHER GROUPS ON BEHALF OF ENGINEERING EDUCATION

Assistance Rendered by Other Organizations

The state societies that completed their project through the first funding stage reported that their efforts were almost unanimously assisted by the universities, with local NSPE chapters and employers of engineers being almost equally involved in the projects.

A slightly different pattern was reported by the state societies that had not reached the first funding stage. These states reported the universities most frequently as being involved, followed by employers, technical and professional societies, and local NSPE chapters in that order.

The American Consulting Engineers Council and the American Society of Civil Engineers were most frequently reported to work closely with NSPE state societies in their efforts to secure aid for engineering education. Virtually every technical and engineering professional society has become involved in one state or another. If a strategy was implemented whereby NSPE's state societies became the coordinators of efforts by the technical and professional societies, even more assistance for engineering colleges would probably result.

Industry Involvement

NSPE state societies in California, Texas, Arkansas, Kentucky, Florida, Alabama, Georgia, Michigan, Mississippi, North Carolina, Iowa, Kansas, Nebraska, and North Dakota have all incorporated industry representatives into their efforts to secure aid for engineering education. Industry representatives from the vice-presidential level sit on advisory councils or project committees in most of those states. In addition to providing industry support for the NSPE state society efforts to gain aid for engineering education, industry representatives are also utilized by most states to secure industry contributions to schools of engineering in cash or equipment, and, in a few states, industry representatives help to identify and recruit engineering instructors from industry on either a permanent or full-time basis. Undoubtedly, industry appreciates the importance of high-quality engineering education to corporate growth and prosperity.

Each locale has its own industrial infrastructure and communications network, but the state and local Chambers of Commerce and manufacturers' associations were mentioned most frequently as being responsive and effective supporters of efforts to aid engineering education. Industry's ability to reach and influence major state government decision and policy makers proved to be the key to success in several states. This industry - NSPE state society cooperation is a pattern that should be refined and developed wherever efforts are planned to assist engineering education.

Engineering College Faculty Shortage Project (ECFSP)

As a result of an independent Ad Hoc Industry/Deans Group, ten major corporations have given $100,000/yr. for two years to support a national action program to solve the engineering college faculty shortage problem. That problem is defined as a critically insufficient supply (fewer than 500 new engineering Ph.D.s) for more than 1,600 faculty openings as of the Fall of 1980, and, in addition, a severe shortage of engineering graduate students in the pipeline for a Ph.D. degree. The funding organizations for the project are: AT&T; du Pont; Exxon; General Electric; General Motors; GTE Corp.; Hewlett-Packard; IBM; Rockwell International and Union Carbide. The sponsorship organization is the Educational Affairs Council of the American Association of Engineering Societies (AAES), and the American Society for Engineering Education (ASEE) in Washington provides the secretariat.

AAES has created an Advisory Board to which the project director reports. That seven-member board consists of four people from industry and three from academe. Naturally, the four industry members were selected from the ten corporations providing the funding, and they were initially: Robert K. Armstrong, du Pont; Jerrier Haddad, IBM*; Paul V. Smith, Exxon; Robert P. Stambaugh, Union Carbide. The three deans are: William M. Kays, Stanford; Robert H. Page, Texas A&M; Paul E. Torgersen, Virginia Polytechnic Institute, and they were chosen to give both a geographic and a profile representation.

The project charter includes: laundering existing data and providing such new information as is appropriate to the project for any interested party to use; secondly, collecting and disseminating information on all initiatives -- whether or not generated by the project office -- and sharing them with all interested parties; thirdly, creating and

*Jerrier Haddad retired from IBM and was replaced by Jack M. Grout of Hewlett-Packard.

proposing viable initiatives that are both practical and capable of fast implementation; lastly, providing a publications facility which will keep all partners (industry, academe including students, and government) and the public informed. In keeping with this last goal, the ECFSP has published a "Catalog of Programs in Industry, Academe, and Selected Institutions to Aid Graduate Engineering Education" and makes it available upon request to: ASEE/ECFSP, 11 DuPont Circle, N.W., Suite 200, Washington, D.C. 20036.

ECFSP reports that although the engineering faculty shortage and Ph.D. pipeline problems continue to represent a crisis, there seems to be a slight improvement in some situations as, indeed, there should be. Many voluntary initiatives have been started. Enrollments have been curtailed by a great many engineering schools. Many corporations and some federal government mission agencies have faced the graduate fellowship and young faculty financial support issues, and new programs have been introduced. Major meetings have been held, such as the National Engineering Action Conference in April 1982 with pretigious industry, academic and government leaders taking strong stands. Many professional and technical societies have rallied their forces and dedicated annual and special meeting agendas to the issues at stake. The universities themselves are finding creative and innovative ways to support engineering faculty and, in particular, their salary structures. More emphasis has been placed on "teaching technology" experiments to multiply the effectiveness and productivity of engineering teaching. New graduate-level cooperative education programs are being tried at a number of schools, (e.g., Lehigh, Carnegie-Mellon). Creative ways of using qualified industry personnel to teach at the college level are being studied, and the traditional "adjunct faculty" relationships are undergoing a sophisticated overhaul on many campuses. The ECFSP will coordinate a cooperative contract team-teaching program between a major industry and a large state university.

Chapter 4

GUIDELINES FOR DEVELOPMENT OF AN ACTION PROGRAM

Introduction

This segment of the Guide describes the specific steps, methods, groups, documents and other aspects of the efforts of state societies to secure aid for their engineering colleges. For the sake of simplicity and clarity, information obtained from various states has been consolidated into one description, giving careful attention to preserve critical sequences of events and procedural nuances. This approach will enable all interested states to utilize this information as a "how-to-do-it" resource.

Background

Motivation for State Society Involvement in Securing Aid for Engineerng Education

Awareness of potential or existing problems in a state's engineering education programs was generated by one or more of the following entities: articles in technical, professional, trade and other publications; input from the Professional Engineers in Education (PEE); engineering faculty and deans; reports from recent engineering graduates; concerns expressed by industry and government officials. The awareness caused NSPE state society officers and members to ask the critical question: "What is the status of engineering education in this particular state?"

Initiation of State Society Projects to Aid Engineering Education

A formal commitment to a project should be made by the state society Executive Committee or Board of Directors. The commitment should include the outline of a plan for the project, including items such as the following:

A. Who will be responsible for overseeing and conducting the various phases of the project.

B. What data will be compiled on the national and state situation in engineering education.

C. How the data will be collected (survey, phone, committee, on-site visits, etc.) and validated.

D. If a deficiency is found, what will be done specifically to secure the resources, or what policies are needed to correct the shortcomings. In addressing this contingency, many states engaged in what amounted to management gaming exercises which resulted in outstanding plans for securing resources.

Those involved in these projects were of the strongly expressed opinion that having a formal commitment by the state society to both a specific study phase plan and a specific action phase plan is absolutely essential because of the resources involved and the political nature of the undertaking.

Suggested Approach and Procedures

PHASE I. AUTHORIZATION FOR PROGRAM TO AID ENGINEERING EDUCATION

A. Get an official commitment from the state society to pursue a program for ensuring the quality of engineering education in the state.

B. Assign responsibility and provide resources to an existing standing committee or establish a new committee for the purpose, being sure to include an engineering faculty member and dean, major industry representatives (V-P of Engineering or other decision maker), state society members, a manufacturers association representative, alumni group representatives, a representative from the state society's Political Action Committee (PAC), and others who have a serious interest in engineering education and who can contribute significant political and intellectual influence.

C. It is recommended that the committee, whether existing or new, be a permanent working committee. The project could also be assigned as the responsibility of one of the practice divisions. In any case, the responsible group should have broad representation from across the profession.

PHASE II. IDENTIFICATION OF THE PROBLEM

A. Clearly state the nature of the problem as it impacts your state and the nation.

B. For example, attempt to complete the following statement: "The decline in the quality of engineering education will adversely impact the quality of life, economic welfare, and the security of the state and nation for the following reasons . . ."

PHASE III. ESTABLISHMENT OF PROGRAM OBJECTIVES

A. Decide what you plan to accomplish and how you will measure your success. For objectives to serve as management tools, they must be specific and produce measurable results.

B. Attention should be given to both short- and long-range objectives.

PHASE IV. DESIGN OF A FACT-FINDING STUDY

A. Design a study that will permit your group to determine the present status of the quality of engineering education. The study should also establish the immediate and continuing needs of engineering education to develop and maintain quality programs.

B. Decide what data/information should be collected and in what form. Develop a uniform format for data collection that can be used by all universities in your state. The engineering educators on your committee should be able to provide guidance. Also remember that your committee may wish to continue to collect these data on an annual or semi-annual basis; therefore, standardize your definitions and forms. More guidance concerning data collection and evaluation will be provided later in this report.

C. Decide on those whom your group wants to talk to and what your group wants to see. First-hand information and observations are considered to be very important if not imperative. See for yourself! Compare industrial and commercial facilities with university facilities. At the minimum, talk with deans of engineering and representatives from professional practice (government, consulting, industry).

D. Decide if you wish to use outside consultants. Such individuals can lend considerable credibility to the findings and recommendations of the committee. Academic and industrial members of your committee can suggest persons.

PHASE V. DATA/INFORMATION COLLECTION

A. As general background, accumulate national data from magazine and newspaper articles, as well as from authoritative reports. The NSPE Engineering Times and ASEE Engineering Education are

good continuing sources of information. It is suggested that a file or mini-library be established for ready reference. Recommended publications are given in the list of references.

B. Seek and collect any information (or opinions) available concerning the relationship between high-quality engineering education programs (instruction, research, and service) and the economic development of your state. That is, is the location of businesses in the state (with the resultant jobs and taxes) due wholly or in part to the existence of a strong engineering program? For example, the newsletter Research Institute Recommendations (Vol. 33, No. 28, 1982) stated that "For hi-tech (businesses), local academic resources are key for plant locations."

C. Identify the specific schools for which the data are to be collected and secure the name, address, and telephone number of the dean of engineering in each of those schools. The state society office will likely have this information.

D. In collecting, comparing, and interpreting data and information, it is important to recognize the different missions (purpose) of the various universities within your state. Major comprehensive universities having a teaching, graduate studies (through the Ph.D. degree), and research mission should not be compared to a university with an undergraduate program only. The mission of each state university has generally been defined by a board of regents or similar body. This information is often found in the catalog of each university.

E. In all cases, historical data that will illustrate trends should be solicited. These data will assist in answering questions concerning whether engineering education is falling behind, keeping pace, moving ahead, and at what rate. One year's data are unlikely to be very useful or persuasive.

F. Collect data and information through the dean of engineering at each school that can be used to evaluate the quality of engineering education. At a minimum, it is suggested that the following data/information be collected:

1. Faculty Salaries

   (a) Obtain the maximum, minimum, and average salaries for the ranks of assistant, associate, and full professor.

   (b) Determine the current entry-level salaries for assistant professors.

   (c) Secure ASEE and EMC national and regional statistics for comparison of national and regional salary statistics and state statistics. The ASEE information can be obtained from: ASEE, 11 DuPont Circle, N.W., Suite 200, Washington, D.C. 20036 or EMC, 345 East 4th Street, New York, NY 10017.

2. Student/Faculty Ratios

   (a) These data should be collected in accordance with the following definition: Full time equivalent engineering enrollment/Number of full time equivalent engineering teaching faculty.

   (b) It is important that historical data be collected to illustrate trends.

   (c) Most universities have available data that were submitted to the Higher Education General Information System (HEGIS) and that can be secured by the dean of engineering from the university's office of institutional research or the president's office.

3. Student Enrollment and Faculty Positions Data

   (a) Historical undergraduate and graduate student enrollment data should be collected, preferably for the previous 10-year period.

   (b) Any changes in admission/transfer requirements or adoption of enrollment limitations should be identified.

   (c) Historical faculty positions data should be collected for the same period as the enrollment data.

(d) Determine the current faculty vacancy situation by rank.

4. Instructional Resources

(a) Total Instructional Cost per Student Credit Hour in engineering can be secured by the dean of engineering from the HEGIS reports of the university. The amount or percentage of research-generated funds being used to support instruction should be identified.

(b) Instructional Salary per Student Credit Hour.

(c) Net Instruction Resources per Student Credit Hour (Amount (a) - Amount (b)). What percent of this amount is research-generated funds?

(d) Teaching Lab Space per Jr/Sr Enrolled. Must distinguish between totally dedicated space and jointly (teaching and research) used space.

(e) Research Lab Space per Graduate Student. Again, distinguish between dedicated and jointly used space.

5. Laboratory Equipment

(a) Secure valid input from deans on equipment needs broken into a matrix of needs due to:

(i) replacement costs

(ii) new technology

(iii) workload increase

(iv) total by: undergraduate teaching; graduate teaching; research; combination of reasons; and totals

(b) Collect equipment inventory data in accordance with the format given in Appendix B. Comparative data for equipment are available in the NSPE report titled, "ENGINEERING EDUCATION PROBLEMS: The Laboratory Equipment Factor" by Dr. Robert D. Kersten, P.E.

6. Physical Facilities

(a) If possible, create a list of engineering instructional facilities in the state, school by school, including the original date of construction, intended capacity, expansion, dates, capacities, and present enrollments.

(b) Prepare a realistic assessment of the present condition of the physical facilities (i.e., classrooms, offices, laboratories, etc.).

(c) Create a school-by-school list of space needs, corresponding costs, and what actions have been taken to meet those needs; e.g., "under construction" or "in legislative request for current year".

PHASE VI. DATA/INFORMATION SYNTHESIS AND EVALUATION

A. In this phase the data/information should be synthesized and evaluated relative to their implication concerning the quality of engineering education.

B. In attempting to establish the relationship between the quality of engineering education and program factors (the six items listed under V.F), a quotation from a Florida Engineering Society Report is appropriate.

> "Quality in higher education can be said to result from the interaction of four tangible ingredients: faculty, students, equipment and libraries. A reputation for excellence in one or more of these ingredients helps to attract, inspire and improve excellence in the other ingredients, because it is an indication of what may be the most important ingredient of all, an intangible one: the commitment to excellence."

C. Potential deficiency or problem areas can be identified using the collected data and ASEE planning factors. However, it is important to state that the factors used to assess engineering education program resources and status do not directly measure program quality. They do measure resources and conditions which influence the quality of programs.

D. Reliance should be placed on the deans of engineering, with verification by the committee and possibly a group of external consultants, to identify the critical needs (short and long term) of their respective colleges.

E. Play "devil's advocate" with the data needs. Do the data support the needs? Can strong arguments be made to support the recommendations for action?

F. Establish a prioritized list of recommendations to improve the quality of engineering education. Give top priority to the most critical needs that can be solved most readily in the short term. However, take care to ensure that none of the suggested solutions are represented as "quick, one-time fix" approaches. The program of aiding engineering education must be responsive to the continuing needs of universities, not just the immediate needs.

PHASE VII. REPORT PREPARATION

A. A well-written report summarizing the findings and recommendations of the committee, supported by the appropriate data, should be prepared. All the basic data and information should be contained in the appendices of the report. All data sources and definitions should be clearly cited.

B. After the report has been reviewed and approved by the state society's executive board, a limited number of copies should be published by the state society. This publication will represent the "source document."

C. An executive summary of the source document should be prepared containing the basic findings and recommendations of the committee. The source document should be clearly referenced in the executive summary and made available, upon request, to interested persons. A model for the executive summary is one

prepared by the Illinois engineering society. A copy may be obtained by writing: Illinois Society of Professional Engineers, 1304 South Lowell, Springfield, Illinois 62704.

D. In general, the principal audience for the executive summary will be legislators, aides to legislators, and, possibly, boardsof regents. It is extremely important that the document be a first-class, concise, well-written, and hard-hitting publication. In effect, it is a sales document. To the extent possible, use graphical presentations to illustrate significant issues and make projections. It must make the point that supporting quality in engineering education provides an excellent return on investment.

E. While the ultimate responsibility for preparing and interpreting the report rests with the committee, it is helpful to have an advisory council comprising industry representatives (chief executive officers, vice presidents for engineering, etc.) to react to the report, conclusions and recommendations, and to help assemble political and industry support to meet the needs of the state's engineering colleges.

F. Include a discussion of the increasing demand for better-prepared engineering practitioners and researchers and the implications for faculty, facility, and equipment needs.

G. Note that increasing student enrollment pressure on facilities precludes "multiple use" of certain space for fairly long periods of time safety of facilities must be ensured.

PHASE VIII. DEVELOPMENT OF ACTION PLAN

A. Design an information dissemination and legislative action program to address the needs of engineering education. Prepare a timetable for critical events that considers whether the state legislature meets annually or every other year. The prioritized recommendations developed in Task VI.F plus the Executive Summary provicd the basic information for pursuing the program. The "resource document" can be used to supplement the recommendations and Executive Summary Report if necessary.

B. Suggested recipients of the "action documents" include: the media; industry and governmental executives; members of the legislature; members of state development boards; officials of appropriate state agencies; members of university governing bodies; university administrators; engineering faculty members; members of the engineering profession, etc. Politically speaking, it would probably be appropriate to give the various individuals and groups an opportunity to review the documents before the information is released to the media. Your Political Action Committee (PAC) should be able to assist in this matter.

C. Welcome an independent evaluation or validation of the recommendations for action. In fact, you may want to suggest that such an effort be undertaken.

D. Utilize your PAC to assist your committee to "lobby" for the recommendations made by the committee. However, it is vital that all persons involved in lobbying efforts be extremely well prepared and knowledgeable. In addition, all persons involved must present a consistent message.

E. Recognize that the effort to secure aid for engineering education is a long-term proposition. Push for immediate help but stress that continuing support must be provided to ensure quality in the long term.

F. All efforts should be well coordinated and very professionally accomplished. Records of contacts and reactions of persons should be maintained and evaluated regularly. A report of each contact should be provided on a timely basis to each person participating in the effort.

G. Whatever methodology is utilized, the project must have a central coordinator to minimize duplication of effort and to assure that all contacts are made. Communications must be outstanding between the central coordinator and those performing the various activities, and the central coordinator must work closely with the state staff.

H. Sensitivity and tact must be evident throughout the project in every participant or the effort can be sidetracked. For example, university presidents are confronted with a serious deterioration of resources and skyrocketing needs for funds.

Conducting an effort on behalf of the engineering colleges might be perceived by some presidents as an invasion of their area of responsibility and authority. This perception could complicate the situation and result in negative reaction to a state society's efforts. The president is the supervisor of the dean of engineering, which puts the dean in an uncomfortable position. Discuss with the dean of engineering how best to inform the president and secure cooperation.

I. Develop a system of feedback so that effective methods can be continued and ineffective methods can be discontinued. Similarly, persons sympathetic to the needs of engineering education can be identified and utilized effectively to assist in the effort from the "inside."

Chapter 5

CASE STUDIES

Introduction

Three case studies have been compiled to illustrate how the Alabama, Florida and Texas state societies proceeded with their successful projects to secure aid for engineering education in their respective states. There are other success stories that could be included, but space limitations necessitate that only three cases be described. Selection of Florida, Alabama and Texas was made because each has a unique aspect that might be of interest to other state societies.

The three case studies and other results decribed in this report are evidence that considerable influence can be effected by state societies of professional engineers on behalf of the state's colleges and universities in legislative enactments. However, great care must be employed in how to approach the state legislature and governor's office. In some states it is permissible for state employees (i.e., deans of engineering and professors) to discuss university budgets with members of the legislature. In other states, it is expressly prohibited. University presidents should always be informed well in advance of any effort on behalf of the university so that the president's endorsement of the action is obtained. All three case studies that follow reflect this careful planning and astute sensitivity to the educational and political realities of the state.

Alabama

Alerted to the nationwide problems in engineering education by articles in ENGINEERING TIMES and other publications and input from engineering educators who are active in the Alabama Society of Professional Engineers (ASPE), the ASPE President appointed a committee to prepare a position paper on the status of engineering education in Alabama.

The Study Committee prepared a questionnaire as a guide to surveying the deans of engineering on a confidential basis. The information collected through the survey was compiled into a report documenting the specific problems and placing them into a historical context of statistics from 1975 to 1982. The report was distributed to members of the Alabama legislature, Commission on Higher Education, Engineering vice presidents of key industries, executive branch offices

and the media. A key feature of the report was its being phrased in positive language rather than negative, and its being sensitive to the political realities of the state. To improve communication, ASPE prepared a slide show of the highlights from the report.

Priorities identified were faculty shortages, instructional laboratory equipment, and facilities. The outcomes of the project were:

1. A $5-million industrial grant to Auburn University from a construction company toward a new engineering facility building program.

2. Legislation of $14 million for engineering education in Alabama.

3. Establishment of an Engineering Education Review Board within the ASPE to annually review the status of engineering education. The Review Board will consist of seven PEs serving two- to four-year terms, will meet twice annually, be selected by the ASPE Board of Directors from a pool made up of two nominees from each local chapter of ASPE, and will fit the following backgrounds:

   - one vice president of engineering from a firm employing 100 engineers or more.
   - one vice president of engineering from a manufacturing firm having $100 million or more annual sales.
   - one vice president of engineering from a manufacturing firm having annual sales between $25 million and $100 million.
   - one PE employed in a civil service position responsible for 100 or more engineers.
   - one dean of engineering in Alabama with responsibility for ABET-accredited curricula.
   - one vice president of a consulting engineering firm.
   - one state ASPE officer.

This Review Board is intended to be influential as well as knowledgeable and experienced in engineering from several employment perspectives.

4. A differential salary increase for engineering faculty at the University of Alabama at Birmingham.

5. Working toward a 14-16% pay raise for higher education faculty.

ASPE accomplished all of this in a period of just over 18 months to prepare and finalize the report and approximately eight months of legislative lobbying and promotion in industry.

For further details contact Joe W. McCollough, ASPE Executive Secretary at (205) 934-2641.

Florida

Engineering educators, working through the Education Committee, raised the problems of Florida's engineering schools to a sufficiently high level of awareness to have them included in the overall FES legislative program. A comprehensive, valid, and reliable status report built around "the quality of engineering education in Florida" as a theme was the basic ingredient. Information from the report was selected to be used to create an "issue sheet" for use in the FES Legislative Forum wherein FES chapter members were briefed and prepared to actively participate in a concerted lobbying effort throughout the branches of Florida government. The issue sheet contained prioritized legislative goals.

On another front, the Florida Board of Regents was made aware of the seriousness and implications of the FES report findings. It was crucial to thoroughly understand the step-by-step procedures of how financial resources are proposed in legislation and processed through committees of the legislature; which parts of the bureaucracy are asked for inputs; the methods by which appropriations to education are further divided into the higher education share; the politics of allocating that higher education share among the universities and colleges of the state; and, finally, how the funds are distributed to the departments and projects within the specific university. Lacking a single piece of this procedural insight can result in unnecessary complications or even failure to gain assistance for engineering education. FES recognized this at the outset and orchestrated its efforts to insure that all relevant individuals and committees were kept aware of the need to give engineering education special consideration and treatment.

Organizationally, FES kept the project streamlined and not bureaucratic. Volunteers, once recommended by the local FES chapter, were guided by the State Legislative Committee. A direct line of communication with the involved members was maintained without the use of intermediaries at the local chapter level.

Two years of activity were involved from the start of the project to passage of the appropriation for engineering education: one year to organize and prepare the report and one year to make the legislative effort.

State staff played an important role throughout the project providing office services, maintaining communications, providing day-to-day coordination of the effort, and guiding the legislative strategy.

The findings of the report and developments throughout the project were kept at a high level of FES member cognizance by an outstanding integration of this information into the FES publication, JOURNAL: FLORIDA ENGINEERING SOCIETY.

Accomplishments of the FES project include:

1. Appointment of an FES representative to the Florida Board of Regents Task Force on Science, Engineering and Technology Service to Industry.

2. Appropriation of $3 million over and above the regular funding in 1981-82 for quality improvement of the state's five engineering schools.

3. Passage of legislation requiring graduation from an accredited school of engineering as a prerequisite to taking the professional engineering exam.

4. Establishment of a new Ph.D. engineering program at the University of Central Florida.

5. Inclusion of $13 million for engineering education in an appropriation bill now under consideration for 1982-83.

Having achieved its first priority goal, the FES has targeted instructional laboratory equipment and facilities for their 1982-83 legislative efforts utilizing the same strategy.

For additional information, contact Dennis Barton, Executive Director, FES, at (904) 224-7121.

Texas

The Texas Society of Professional Engineers (TSPE) three years ago undertook a highly detailed, school-by-school, engineering education needs study at the request of their Education Committee and Professional Engineers in Education Committee. This tedious, detailed research effort culminated in a 1982 report titled, A CRISIS IN ENGINEERING IN TEXAS.

These findings, prior to publication, were formally presented by TSPE to the Division of Financial Planning Coordinating Board, Texas College and University System. In that presentation, the state's financial allocation formula was analyzed and recommendations for changes suggested. The remainder of the TSPE strategy followed the patterns described for Florida: media, state legislature, industry, educators, and so on. By stringently insuring that all relevant parties were kept informed regularly and maintaining an aggressive but positive effort, TSPE was able to secure aid for engineering education in the state. The unique aspect of the TSPE effort was the quality and quantity of skillfully and professionally prepared data that were utilized. It precluded delays in considering the TSPE requests for action.

TSPE accomplished the following:

1. Engineering faculty received a larger percentage increase in pay than the system-wide increase.

2. The legislature is considering special funding for engineering instructional laboratory equipment ($50 million, one-time).

3. The magnitude of engineering education's needs in Texas has been documented and has attracted the serious attention of those who legislate and allocate financial resources.

For additional information regarding the TSPE's experience, contact Charles Space at (512) 472-9286.

Experience in Other States

Other successful state societies have utilized innovative approaches that meet their particular needs such as:

1. An Industry Advisory Council can be used to review the report and action plan and to generate industry support.

2. The Legislative Committee of the state society can proceed without a "Legislative Forum," and Minutemen and Political Action Committee activities can be included.

3. Kansas used a "position paper" instead of a formal research report.

4. Nebraska utilized the Governor's Task Force on Job Improvement to make their state's engineering education needs known.

5. State societies in California, Kentucky and elsewhere joined with powerful industry groups in their respective states to press for aid for engineering education.

6. In New Mexico and several other states, the universities have ongoing organized efforts to secure financial support and the state societies back them professionally and politically. Deans of engineering and faculty almost universally support the effort and provide hard data but usually work behind the scenes.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

Engineering education quality and needs can effectively be monitored by state societies of professional engineers working closely with engineering faculty, department heads, deans, presidents, and regents. These needs can be translated into effective legislation requests and details for consideration by business and industry for contributions where needs are of critical proportions, legislatures and governors can best be persuaded to provide assistance when the backing of business and industry is incorporated into the state and local chapter lobbying efforts.

Technical and professional societies (engineering) provided effective support to the NSPE state society efforts in only a few instances. Lacking a state structure of their own, it is recommended that each NSPE state society establish working relationships with the local chapters of other technical and professional societies to bring greater influence to bear on those who allocate resources to engineering education.

Relationships between engineering educators and NSPE state societies appear to be well developed and effective. A weaker relationship exists between the NSPE state societies and university presidents and regents. Therefore, it is recommended that the NSPE state societies continue working to establish good relationships with engineering educators, university presidents and regents and to keep them accurately informed on engineering concerns and developments.

NSPE state societies and their constituent chapters and members are a very capable lobbying team when addressing a carefully defined issue. The achievements of those state societies that have completed the first funding phase are a source of pride to the entire engineering profession. They are willing to assist other state societies to undertake projects to aid engineering education. It would be remiss not to acknowledge their efforts and to recommend that all states establish a standing committee to ascertain the status of engineering education annually, to develop good working relationships with the higher education community, and to carry out coordinated lobbying activities to insure that the documented needs of engineering education are considered and met.

Successful projects by NSPE state societies to gain aid for engineering education had in common careful planning, valid and reliable data professionally presented, outstanding coordination, and a positive approach to solutions. It is recommended that the state societies include those elements in their projects along with a thorough understanding of state fiscal procedures and industry priorities.

An estimated $1.1 billion is needed to update and repair engineering instructional laboratory equipment to the minimum acceptable level. Considering faculty-related problems and engineering education facility needs nationwide, engineering education's needs are extensive in terms of dollars. The results and efforts described in this report reflect an appreciation of the problem in various states by engineering educators, university presidents and regents, legislators, industry and business leaders, and members of the engineering profession. Most importantly, through the democratic processes inherent in these states, significant allocations of scarce state resources have been directed toward at least easing the pace of deterioration of engineering education. Federal assistance of any significance is not evident in the present budget in spite of national economic, defense, and social concerns. Unless the federal government provides a major funding program to help state governments and industry improve engineering education to an internationally competitive level, the amount of funding could tragically be too little, too late. That risk is too great. It is recommended that NSPE and the other engineering societies conduct an unrelenting lobbying drive to move the President and Congress of the United States to legislate an infusion of funds into engineering education over a period of several years that will be sufficient in amount to once again make American engineering education the best in the world.

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APPENDIX A

SURVEY OF ENGINEERING FACULTY AND GRADUATE STUDENTS FALL 1981

Conducted by

Engineering Manpower Commission
(Paul Doigan, Chairman)

of the

American Association of Engineering Societies, Inc.

for the

AAES/ASEE
Engineering College Faculty Shortage Project
(John W. Geils, Staff Executive)

July 26, 1982

SURVEY REPORT HIGHLIGHTS

- As of Fall 1981, there were an estimated 18,000 full-time engineering faculty positions authorized; 13,000 in public schools, 5,000 in private schools.

- Nine percent (9%), approximately 1,600, of the authorized positions in the nation's engineering schools were unfilled as of Fall 1981; 56% of these were unfilled in Fall 1980, one year earlier.

- Twenty-four percent (24%) of the authorized faculty positions at the Assistant Professor rank were unfilled in Fall 1981; 56% of these unfilled in Fall 1980.

- Seventy-one (71%) of the engineering schools reported a decrease in their ability to recruit and retain faculty.

    - Greater than 70% of the engineering schools reported an increased teaching load and a greater reliance on Teaching Assistants and Part-time Faculty.

    - More than 47% of the engineering schools reported that some courses were not being offered.

    - Over 32% of the schools reported a reduction in research being conducted.

- Sixty-six percent (66%) of full-time engineering faculty hold tenured positions.

- Almost 81% of full-time engineering faculty hold doctorates.

- Over 17% of full-time engineering faculty received their baccalaureate degree from a non-U.S. university.

- Less than 3% of the engineering faculty are age 66 or older.

- Twenty-two percent (22%) of engineering faculty are age 56 or older.

- Nineteen percent (19%) of engineering faculty are age 35 or younger.

- Public engineering schools lost almost 24% more faculty members who voluntarily accepted positions in industry than the number gained coming from industry.

- Private engineering schools gained almost 64% more faculty members from industry than the number that voluntarily left for industry.

- Fifteen percent (15%) of all engineering graduate students are attending schools from which they received their baccalaureate degrees.

- Non-immigrant foreign students account for over 32% of the engineering graduate school population; over 41% of the post MS-students.

- Almost 41% of all teaching assistants in engineering graduate schools are foreign students.

SURVEY INFORMATION

Following up on the American Council on Education report on the "Recruitment and Retention of Full-Time Engineering Faculty, Fall 1980," this survey was conducted to reassess the extent of faculty vacancies in colleges of engineering, the effects of these vacancies upon research and instructional programs and to gather information on the characteristics of both the engineering college faculty and engineering graduate student populations.

This survey extended question #4 of the ACE survey to obtain information by faculty rank on authorized and unfilled full-time faculty positions in the nation's engineering schools and duplicated questions #2 and #3. Question #5 expanded a similar question in the ACE survey to capture information regarding the flow of industry people to academic positions in engineering schools. Other questions in the survey were designed to gather information on faculty characteristics, i.e. tenure, doctorates, foreign education, age distribution, salary, etc.; and on graduate student characteristics, i.e., U.S. students, foreign students, post-MS population, salaries, etc., for all engineering schools and for Chemical, Civil, Electrical and Mechanical Engineering Departments.

The letter accompanying the survey was addressed to the Dean of Engineering and sent on January 22, 1982 to each of the 284 schools offering a baccalaureate or higher degree in engineering using the Engineering Manpower Commission mailing list. Follow-up telephone calls were made at the end of February and again at the end of March.

One hundred and ninety-four (194) schools returned the survey; however, several schools could not be identified and were not used in the analysis.

The data for authorized full-time faculty positions submitted by the 165 schools responding to this question were extrapolated to give an approximation of the total authorized full-time faculty positions in all engineering schools using the ratio of full-time enrollments (undergraduate and graduate) for the respondent schools to the total enrollments for all schools as reported in the EMC Survey, Engineering and Engineering Technology Enrollments, Fall 1981.

All other analyses discussed in the report are based only on the data as reported by the schools responding. One hundred and two (102), or approximately 61% of the public institutions, and 68, or about 62% of the private institutions, were represented in the survey data.

This initial report will be reviewed by a Committee of the Engineering Faculty Shortage Project. Recommendations will be made for further analysis of the existing data and modifications, as appropriate, for the follow-on survey which is to be conducted in early 1983.

SURVEY RESULTS

Faculty Recruitment

The inability to recruit and retain engineering faculty continues to be a major concern for many of the nation's engineering schools. However, overall, there appears to be an improvement over that which was reported by the American Council on Education for Fall 1980. Over 34% of the engineering schools in this survey reported a substantial decrease in their ability to recruit and retain faculty in Fall 1981. More than 42% of the public schools reported a substantial decrease in their ability to recruit while only 22% of the private schools reported such a decrease. Overall, although 71% of the engineering schools still reported a slight, moderate or substantial decrease in their ability to recruit and retain faculty in Fall 1981, this is a marked increase over the 88% reported for Fall 1980 by ACE*.

TABLE I
Change In Ability To Recruit And Retain Faculty

Degree of Change	Public Schools	Private Schools	All Schools
Substantial Increase	4.9%	5.9%	5.3%
Slight/Moderate Increase	6.9	17.6	11.2
No Change	5.9	22.1	12.4
Slight/Moderate Decrease	40.2	32.4	37.1
Substantial Decrease	42.2	22.1	34.1
All Degrees of Change	100%	100%	100%

The effects of this inability to recruit faculty are most important to the well-being of our engineering education system. Reductions in their ability to carry on research were reported by over 32% of the universities. Seventy-one percent of the schools reported an increase in teaching load and 72% reported a greater reliance on part-time faculty and teaching assistants to effectively cope with the increased undergraduate enrollments. In almost 48% of the schools, a number of courses could not be offered because of the lack of appropriate faculty. Only 5.8% of the institutions reported that they have experienced no significant effects due to their inability to hire full-time faculty.

* Recruitment and Retention of Full-Time Engineering Faculty, Fall 1980; Higher Education Panel Report Number 52, American Council on Education, October 1981.

TABLE II
Effect Of Inability To Recruit And Retain Faculty

Effect	Public Schools	Private Schools	All Schools
Reduction in Research	33.7%	29.7%	32.5%
Increase in Teaching Load	75.9	59.5	70.8
Greater Reliance on Teaching Assistants or Part-Time Faculty	75.9	62.2	71.7
Course Not Offered	47.0	48.6	47.5
No Significant Effect	4.8	8.1	5.8

Faculty Vacancies

Based on the survey data from the 165 schools reporting data, it is estimated that there were 18,000 authorized full-time faculty positions in the 284 engineering schools in the United States in Fall 1981. The private schools account for approximately 5,000 of these positions and the public schools approximately 13,000. The three basic disciplines account for the major share of the authorized positions: electrical engineering accounts for 23.5%, mechanical for 19.5% and civil for 16.7%.

TABLE III
Percentage Distribution of Authorized
Full-Time Engineering Faculty Positions
Fall 1981

Engineering Field	Public Schools	Private Schools	All Schools
Aero & Astronautical	4.4%	3.3%	4.1%
Chemical	7.9	9.9	8.4
Civil	17.4	14.8	16.7
Comp. Sci. & Comp. Eng'g.	4.9	4.1	4.7
Electrical	22.0	27.3	23.5
Industrial	5.4	3.4	4.8
Mechanical	18.7	21.3	19.5
All Others	19.3	15.7	18.2
All Schools	100%	100%	100%

Nine percent of all faculty positions, or approximately 1,600 based on an estimate of 18,000 full-time authorized positions, were reported as unfilled as of Fall 1981. Of these unfilled positions, 56.1% were unfilled since Fall 1980, one year earlier. The public schools reported 9.5% of their authorized positions unfilled in Fall 1981 with 58.9% of them unfilled one year earlier, while the private schools appeared to have less of a problem and reported a vacancy rate of only 7.9% with 47.3% unfilled in Fall 1980.

TABLE IV
Engineering Faculty Position Vacancies

	Estimated * Authorized Positions	Unfilled Positions In Fall 1981	FALL 1981 Positions Unfilled In Fall 1980
Public Schools	13,000	9.5%	58.9%
Private Schools	5,000	7.9	47.3
All Schools	18,000	9.0	56.1

*Extrapolated Using Enrollment Data

The largest number of vacancies were reported for the three basic disciplines (electrical, mechanical and civil engineering). Computer science/computer engineering, which accounts for about 4.7% of the total authorized engineering faculty positions, reported a shortfall of 17% in Fall 1981, with 63.3% of the positions being unfilled in Fall 1980. Industrial engineering, accounting for about 4.8% of the authorized positions, reported a vacancy rate of 11.6%, of which 50.7% were unfilled in Fall 1980. A vacancy rate of 24.4% was reported at the Assistant Professor rank which is the entry level at most schools; however, the entry level at a number of schools is at the Instructor/Lecturer rank which was reported at a vacancy rate of 10.9%. Fewer vacancies were reported for the Associate and full Professor ranks.

TABLE V
Unfilled Positions As A Percentage Of
Authorized Full-time Positions--Fall 1981

Engineering Field	Public Schools	Private Schools	All Schools
Aero & Astronautical	5.9%	2.6%	5.1%
Chemical	9.0	8.2	8.8
Civil	8.7	6.8	8.2
Comp. Sci. & Comp. Eng'g.	17.0	16.8	17.0
Electrical	8.8	7.9	8.5
Industrial	11.6	11.8	11.6
Mechanical	9.5	7.6	8.9
All Other	9.3	7.2	8.8
All Schools	9.5	7.9	9.0

TABLE VI
Unfilled Engineering Faculty Positions

	As Of Fall 1981	Fall 1981 Positions Unfilled As Of Fall 1980
Professor	3.4%	57.6%
Associate Professor	6.4	54.1
Assistant Professor	24.4	56.4
Instructor	10.9	53.2
All Ranks	9.0	56.1

Faculty Characteristics

The survey requested information with respect to tenure, academic achievement and education background of the faculty in engineering schools and in four major disciplines - chemical, civil, electrical and mechanical

engineering. Schools reported that 66.1% of the full-time faculty in engineering held tenured positions and 80.8% of their full-time faculty held doctorates. Overall, 17.4% of the faculty in U.S. engineering schools received their baccalaureate degree from a non-U.S. institution -- 26% of the Assistant Professors; 16.7% of the Associate Professors and 15.6% of the Professors. Private schools reported that 19.2% of their faculty held non-U.S. baccalaureate degrees while public institutions reported a rate of 16.6%. With respect to tenure, public schools reported 67.9% versus 61.8% for private institutions. The percentages of faculty holding doctorates and those employed in the schools from which they received one or more of their degrees were not very different for public and private schools.

TABLE VII
Engineering Faculty Characteristics
Fall 1981

Characteristic	Public Schools	Private Schools	All Schools
Tenured	67.9%	61.8%	66.1%
Have Doctorate	80.4	81.8	80.8
Non-U.S. BS Degree	16.6	19.2	17.4
Own Graduate	17.9	18.2	18.0
Estimated Total Faculty	13,000	5,000	18,000

Chemical and electrical engineering faculties reported higher percentages of doctorates, at 91.9% and 82.8% respectively, then those reported for total engineering faculties, while civil and mechanical engineering reported lower percentages at 79.9% and 78.9%. Civil engineering reported the largest percentage of foreign educated faculty at 19.6%; however, electrical, chemical and mechanical engineering also reported percentages above those for all engineering faculty. At the Assistant Professor level, chemical engineering departments reported that 32.9% of their faculty received their baccalaureate degree from a foreign university--almost seven percentage points greater than that reported for all engineering faculty members.

Chemical engineering departments reported that 13.6% of their own students were on their faculties, while electrical engineering departments reported almost 21%. These are significantly different from the 18% reported for all disciplines.

TABLE VIII
Engineering Faculty Characteristics
Fall 1981

	Chemical	Civil	Electrical	Mechanical
Tenured	66.6%	65.8%	67.7%	68.5%
Have Doctorate	91.9	79.9	82.8	78.9
Non-U.S. BS Degree	17.5	19.6	18.2	17.9
Own Graduate	13.6	17.9	20.9	18.4
Estimated Total Faculty	1,300	2,700	3,900	3,100

Less than 3% of all engineering faculty members are age 66 or older; 19.4% are in the 56-65 age group; 29.1% are 46-55; 29.7% are 36-45 and slightly over 19% are age 35 or younger. Private schools reported 22.6% of their faculty members in the age 35 or younger group, which was a higher percentage than for the public schools which reported 17.9% in this age group. In the over-66 age group, public schools showed almost 3% while private schools showed only 1.5%.

TABLE IX
Age Distribution Of Engineering Faculty
Fall 1981

	Public Schools	Private Schools	All Schools
70-	0.4%	0.2%	0.3%
66-70	2.5	1.3	2.2
56-65	19.5	19.3	19.4
46-55	29.3	28.6	29.1
36-45	30.4	28.1	29.7
26-35	17.4	21.5	18.6
-25	0.5	1.1	0.6

TABLE X
Age Distribution Of Engineering Faculty
Fall 1981

	Chemical	Civil	Electrical	Mechanical
70-	1.3%	1.1%	0.5%	0.4%
66-70	2.9	2.1	1.8	2.1
56-65	16.7	18.3	18.4	22.1
46-55	26.6	29.3	28.8	30.0
36-45	28.7	31.5	31.3	27.9
26-35	22.6	17.3	18.7	16.3
-25	1.3	0.5	0.4	1.1

Chemical engineering departments show a significantly higher proportion of faculty members in the under-age-35 category while civil engineering shows a lower percentage than that reported for all deparments combined in this age category. Chemical engineering shows 4.2% of faculty members in the over-66 age category--significantly higher than that shown for the other disciplines.

Faculty Mobility

Two hundred and sixty-six engineering faculty members voluntarily left academic positions to accept full-time employment in industry and 251 engineers employed in industry accepted full-time appointments on faculties of the 137 engineering schools that responded to this question in the survey.

TABLE XI
Industry/Engineering School Faculty Mobility
1980-81 Academic Year

	Public Schools	Private Schools	All Schools
Voluntarily Left Faculty For Industry	211	55	266
Joined Faculty From Industry	161	90	251

Although the "All Schools" numbers appear to be in balance, the public schools experienced a much higher percentage flow of individuals to industry than did the private schools. Only 76.3% of the number of people who voluntarily left public universities for positions in industry were offset by individuals who left industry for positions in public engineering schools. Possibly reflecting the ability of private schools to pay higher salaries for experienced faculty people, the private schools reported the reverse flow. Almost 64% more people left industry to accept academic positions in private schools than the number that voluntarily left academic positions for work in industry.

Faculty Salaries

The salaries reported for Professors ranged from $64,700 to $20,000 with an average of $35,320; the highest salary was reported by a private school while the lowest salary was reported by a public institution.

At the Associate Professor level, a range of $45,350 to $16,000 was reported with an average of $28,100; both the highest and lowest salaries were reported by public schools. At the Assistant Professor level, the average of $24,080 was reported with a range of $35,860 to $12,720; again, both the high and low salaries were reported by public institutions.

TABLE XII
Engineering Faculty Salaries
(Average 9-Month Basis)

	Public Schools	Private Schools	All Schools	Range
Professor	$35,530	$34,980	$35,320	$64,700 - 20,000
Associate Professor	28,230	27,890	28,100	45,350 - 16,000
Assistant Professor	24,040	24,110	24,080	35,860 - 12,720

Graduate Student Characteristics

U.S. students account for approximately 65% of all graduate students enrolled in the nation's engineering schools. Thirty-two percent (32%) of the remainder are foreign students classified as non-immigrant and 3.0% are classified as immigrants. A higher percentage of the graduate students enrolled at public schools are classified as non-immigrants compared with those enrolled at private schools.

TABLE XIII
Graduate School Population Characteristics
All Students

	Public Schools	Private Schools	All Schools
U. S. Students	63.4%	66.7%	64.5%
Immigrants	3.0	3.1	3.1
Non-Immigrants	33.6	30.2	32.4
Own Undergraduates	15.6	14.1	15.1

At the post-MS level, the percentage of U. S. students reported decreased to 55%. Non-immigrants account for 41% of the post-MS level graduate student population and immigrants represent almost 4%.

TABLE XIV
Graduate School Population Characteristics
Post-MS Students

	Public Schools	Private Schools	All Schools
U. S. Students	52.8%	58.7%	55.2%
Immigrants	4.4	2.6	3.7
Non-Immigrants	42.8	38.7	41.1
Own Undergraduates	11.0	7.2	9.5

Fifteen percent of graduate enrollments are made up of students who received their baccalaureate degrees at the same engineering schools at which they are enrolled for graduate study. However, at the post-MS level, this decreases to 9.5%. These numbers are reported to be lower, 14.1% and 7.2% respectively, by the private schools and higher, 15.6% and 11.0%, by the public engineering schools.

The highest percentage of foreign national graduate students was reported by chemical engineering departments. They reported that 39% of their graduate students are non-immigrant foreign nationals with this number increasing to 41.5% at the post-MS level. Civil engineering reported the highest percentage of foreign nationals at the post-MS level. They reported 35.5% non-immigrant foreign national graduate students with an increase to over 46% for post-MS students. Both electrical and mechanical engineering reported approximately 33% non-immigrant foreign nationals and an increase to just over 42% for post-MS students.

APPENDIX B

NSPE/PEE
DEFINITIONS AND INSTRUCTIONS

I. Laboratory Equipment Study Definitions
(Column Headings Correspond to Instruction Code)

A. Fiscal Year

July 1 through June 30. Report all data for 12-month period.

B. Laboratory Equipment Expenditures

Report the total expenditures for each fiscal year for equipment items used for teaching and research. This item is intended to represent the support from institutional funds for laboratory equipment. (Do not report equipment purchased through separately budgeted research.) Data should be for the then-current dollars basis. We will apply appropriate price inflators in our analysis to arrive at 1980-81 dollars. Do not include computer equipment expenditures unless such equipment is directly a part of an instructional laboratory. Exclude central computer center "number crunching" type expenditures.

C. Faculty Man Years

FTE refers to the percent time appointed. The manyear refers to the duration of the appointment.

12 month appointment @ 1.00 FTE = 1 MY
10 month appointment @ 1.00 FTE = .833 MY
9 month appointment @ 1.00 FTE = .75 MY

Report the number of faculty manyears funded specifically for the on-campus instructional program. Instructional activities include undergraduate- and graduate-level teaching, thesis and dissertation supervision, departmental research, counseling, and administration. Do not include manyears for counseling, and administration. Do not include manyears for separately funded research or public service activities. Please report only those persons holding the academic rank of instructor or equivalent, or higher.

D. SCH Produced

Student credit hours (SCH's) are a measure of the instructional load for all courses taught by the engineering faculty during a 12-month period. One student taking a three-semester-hour course for one semester accounts for 3 SCH's. If your institution is on an academic term other than semesters, please make the appropriate conversion and report on a semester basis.

E. Degrees Awarded

Report total number of degrees awarded for the 12-month period July 1 through June 30 each year.

F. Enrollment

Report the number of total head count (for Fall term) of engineering students pursuing full- or part-time programs, freshman through graduate. Similarly, report the number of FTE students (for Fall term) of engineering students, freshman through graduate as determined, e.g., 15 SCH per FTE undergraduate; 12 SCH per FTE graduate.

G. Number of Student Stations

Report the total number of student stations of instructional laboratories and associated equipment, e.g., a typical Electrical Engineering student station. . . 50 square feet of floor space, bench, oscilloscope, power supply, function generator, digital multimeter, etc. The occupancy rate may exceed the number of student stations and stations may be used more or less frequently depending on scheduling frequency. . . however, the given set up of equipment is essential to program operation whether student use is one or one hundred in a given time frame.

H. Separately Budgeted Research Expenditures

Report separately budgeted research expenditures (total $) as typically reported to ASEE Research and Graduate Study survey. (cf, for example, Table C of March issue of Engineering Education.)

I. Base Year Inventory (1970-71)

Please report the dollar value of your laboratory equipment inventory on a "book value" or "acquisition cost" basis. If any other basis is used please so indicate under remarks.

J. Remarks

If reports/data are not available for all years of this study please give best estimates possible and explain under remarks. Please report any apparent anomalies in your data, e.g., where resources are shared with a non-engineering unit, start up of new program(s) or phase out of old program(s), change in accounting basis, etc.

K. Lab Credits Required

Report for typical degree program at your institution the number of required laboratory credits.

II. Discussion

A. Nearly all of this data may have been reported in some years to:

ASEE Planning Factors Study
EMC Enrollment and degree data
ASEE Research and Graduate Study Directory

Please utilize such data for any years for which it may be available and report remaining years on a comparable basis.

B. The objective is to develop several data plots of Figures of Merit vs time for a pilot group of schools considering factors of size, complexity, research activity, number of accredited programs, etc. We will apply depreciation and inflation rates in our analysis. Figures of Merit derivable from the data sought herein include:

1. Dollars/Head Count Student
2. Dollars/FTE Student
3. Dollars/Degree/Level
4. Dollars/Faculty Manyear
5. Dollars/SCH
6. Dollars/Student Station

etc.

COMPARATIVE STUDY
LABORATORY EQUIPMENT INVENTORY/EXPENDITURES
NSPE - PROFESSIONAL ENGINEERS IN EDUCATION

A	B	C	D	E			F	G	H
				Degrees Awarded			Enrollment		
Fiscal Year	Lab Equipment Expenditures ($1,000's)	Faculty Man Years MY	SCH Produced	BS	MS	D	Headcount FTE	No. of Student Stations	Separately Budgeted Research Expenditures ($1,000's)
1971-72									
1972-73									
1973-74									
1974-75									
1975-76									
1976-77									
1977-78									
1978-79									
1979-80									
1980-81									

(I) Base Year Inventory (1970-71) $ _____

Data Reported are for (a) College _____

(b) Program/Dept. _____

Indicate Discipline _____

(J) Lab Credits Required

BS _____

MS _____

PhD _____

(K) Remarks:

Name and Mailing Address of Institution:

_____

_____

_____

Person Responsible for Data:

Name: _____

Telephone: _____

APPENDIX C

INDEX OF ECFS PROJECT LITERATURE

1. Project Description
2. Survey of 32 Deans (Also Engineering Education News, March 1982)
3. Industry Participation re: ECFS and Related Problems
4. March 1982 issue of PE - Professional Engineer magazine (article)
5. March 1982 issue of Engineering Education News (interview)
6. June 1982 issue of Engineering Education News (preliminary survey data)
7. August 1982 issue of Engineering Education News (audited survey data)
8. NEAC Press Kit
9. AAES/ASEE Survey of Faculty and Graduate Students -- Fall, 1981, Final Report, 7/26/82
10. Survey Instrument for EMC Survey of Faculty and Graduate Students
11. ECFS Project Progress Reports: 12/15/81; 4/30/82; 5/31/82; 8/15/82
12. "Alternate Funding for Innovative Programs to Increase Graduate School Enrollment", 6/82 (ASEE 1982 Annual Conference paper)
13. Catalog of Programs from Industry, Academe and Selected Institutions to Aid Graduate Engineering Education, 8/82
14. Geils Testimony before House Committee on Science and Technology, 10/6/81
15. AAES Special Task Force Report to Presidential Science Adviser, 8/82
16. "Engineering Faculty for Tomorrow" (26 min., 16 mm color film)

Note:

Many other documents, such as copies of proposed legislation in Congress; major articles; talks and reports; a wide variety of statistical data; and national and regional activities addressing faculty shortage and Ph.D. problem are on file in the Project office and distributed as requested and/or appropriate.